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COMMUNITY ANTENNA
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OCTOBER
1979

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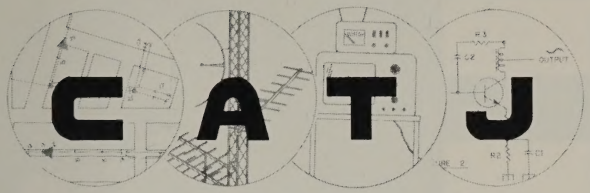

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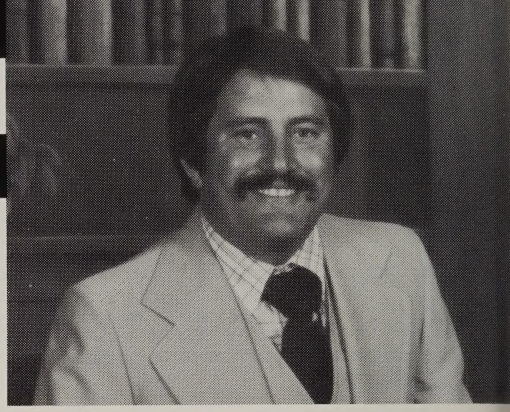

BEN CAMPBELL, President of CATA, Inc.

THE SECOND TIME AROUND?

The economic signs are all around us, and they are confusing. On the one hand, the cable television industry is experiencing another one of its periodic booms—this one looks like it is going to last, and at the same time has some of the same troublesome signs of the "boom" of '72-'73. On the other hand we have the general economic outlook, with the "experts" talking about a recession, or "stagflation", or maybe both, and some people saying it will be a long, slow process while others say it will be mild and short. What does it all mean for the cable industry?

Well, the memories of those of us in the cable industry are not that short that we have forgotten what happened in the early '70s. The FCC, in 1972, ended the "freeze" on cable. there was a great deal of speculation that this would happen, so in '70 and '71 the franchise fighting began. The bidding went crazy. Blue sky promises abounded, and the cable industry got a lot of publicity. After the Commission adopted its new rules there was a little bit of a let-down because the "relaxation" did not really get us out of the woods in a lot of markets with respect to distant signal carriage, etc., but there was enough to go on, and the industry started to build—fast.

As usually happens in a "boom" atmosphere like that, supplies became tight. It was tough to round up enough strand, and converters, let alone find the manpower to install it. The manufacturers worked hard to increase capacity and everything was going at breakneck speed. Then the economy collapsed. Interest rates went through the roof and as they did the "Blue sky" was exposed for exactly what it was. The fun was over. It became almost impossible to get reasonably-priced financing for cable television construction and the rate of construction went down drastically. All that new capacity built up by the suppliers went idle and the "shake-out" of the industry started.

It was not a pretty time. Many franchises never got built. A lot of promises were broken, and the image of cable television was badly tarnished. Of course many folks recognized that part of the problem, at least, was caused by the souring of the economy—after all, we were not the only industry in the same fix. But that didn't save us from having many cities shy away from cable television for quite a few years because of a bad taste in their mouths about the experience they had. We can still remember the headlines in Boulder, and Milwaukee, Boston, and Portland not to mention the many little towns that never got service because of what happened back then.

Five years have gone by, and a lot has happened. The FCC has eliminated a lot more of the rules, and now there is serious speculation that they will get rid of all the signal carriage rules within the next year. Cable has started to fulfill some of the "blue sky" promises it made. The larger capacity systems are now being built, and, of course, there is the satellite. It is all very exciting again. The industry is working at almost a fevered pitch. Sound familiar?

My grandmother always told me that even a donkey doesn't trip over the same stone twice—but I see that stone ahead of this industry again, and I'm getting worried that we are aiming right for it! It is no secret that the franchise bidding wars are on again with a vengeance. This is true even though the FCC still technically has its rules in place about limitations on franchise fees. It doesn't seem to stop some companies from going out and bidding up the fees—even offering huge up-front payments to secure the franchise.

Equipment, once again, is in short supply. You can't go to any trade show—and CATA representatives get to most of them, so we hear what is going on—without hearing the suppliers use terms like "4 to 6 month delivery"! This time, however, it doesn't look like the suppliers will be building new capacity so fast. Even if

they did, the equipment needed is getting so sophisticated that it will take a long time to get any new capacity on line. The shortages are real, and they are being ignored by the franchise fighters who are still going around promising not only unrealistic services and equipment, but also unrealistic construction schedules in order to "win" franchises.

I am beginning to wonder what they are really winning! Are we once again about to fall into the same trap we got into in the early '70s? This country is in the middle of a recession and no one seems to know how long it will last. The prime rate is now higher than it was at its peak in '73-'74. Yet the cable tom-toms are pounding and the promises are gushing forth. Boston and Portland, Boulder and Milwaukee are all getting involved in seeking cable operators again. There is too much de ja-vu here for my liking!

I am not saying we should stop in our tracks. I do not advocate a cut-back in industry builds or in franchising for that matter. What I am suggesting, however, that the industry be very careful in assessing what the situation truly is. That we be very careful to honestly spell out the problems that we forsee and the delays that might be inherent in the situation we now find ourselves in. We cannot afford another crisis in confidence.

What can we do? Well, to begin with I would suggest that whenever there is a franchise competition the true facts be given to the city by ALL the participants. By doing that all parties can be protected from misunderstandings later on, and no one party will get any theoretical advantage by not letting the city know the "bad news" as well as the "good news". This is particularly true in the area of construction timetables. Honesty, it seems, is the best policy. This is especially true when you can't get anything delivered in less than four months these days!

Another suggestion would be for the industry itself to be a little more realistic in what is really happening around us. Certainly pay-cable has been a great boost, as has been satellite delivery of programming. But there are still many clouds on the horizon. The industry trade associations have done an excellent job, it appears, of protecting us from a very bad set of proposals on Capitol Hill. But that is not the end of the battle. CATA's Washington Office is putting out loud warning signals that the expected relaxation of the FCC signal carriage rules may not be so fast in coming—the facts may be on our side, but if we relax now, the politics won't be. Further, there is no question that the idea of "retransmission consent" is still alive—what would that do to a new system if it actually was adopted—kill it, that's what! And of course there is always copyright. Will the rapid building of the country continue if we have to pay three or four times more than we do now in copyright payments?

I'm not saying that any of these dire events will happen, but they can. We are in the middle of a boom and there is a danger that we will forget the necessity of continually protecting our interests lest we lose out to those who do not want to see us grow. Gloom and doom? No. But caution, yes. We must continue to fight for our rights and not let down our guard now just because things seem to be going very well. To forget what happened in the past may doom us to the prospect of repeating it.

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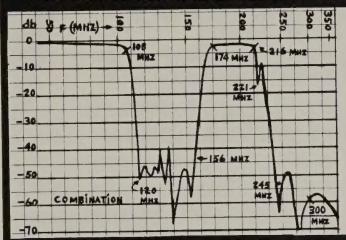

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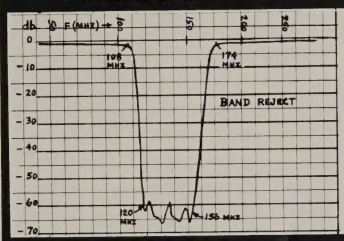

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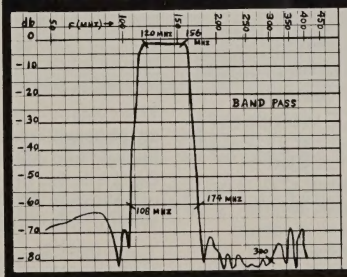

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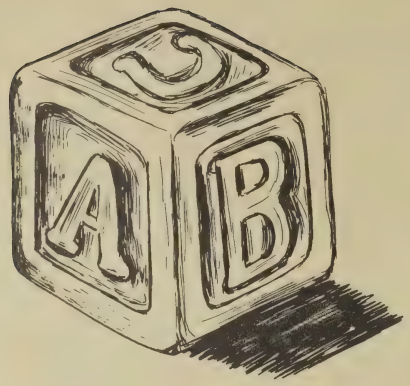

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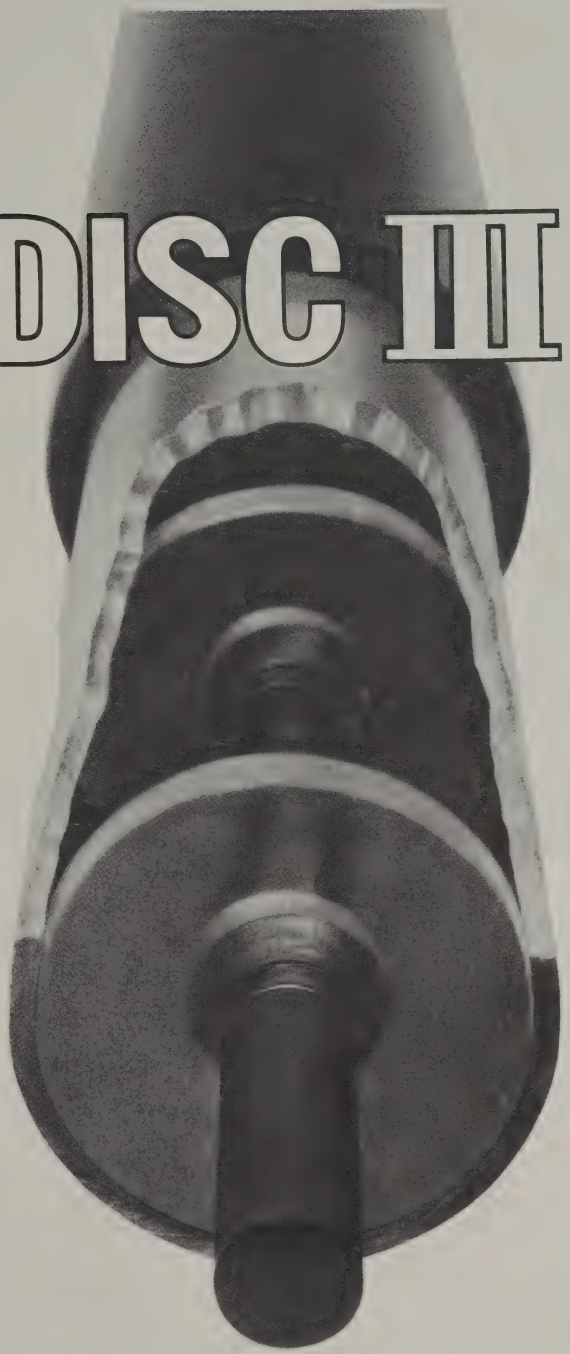

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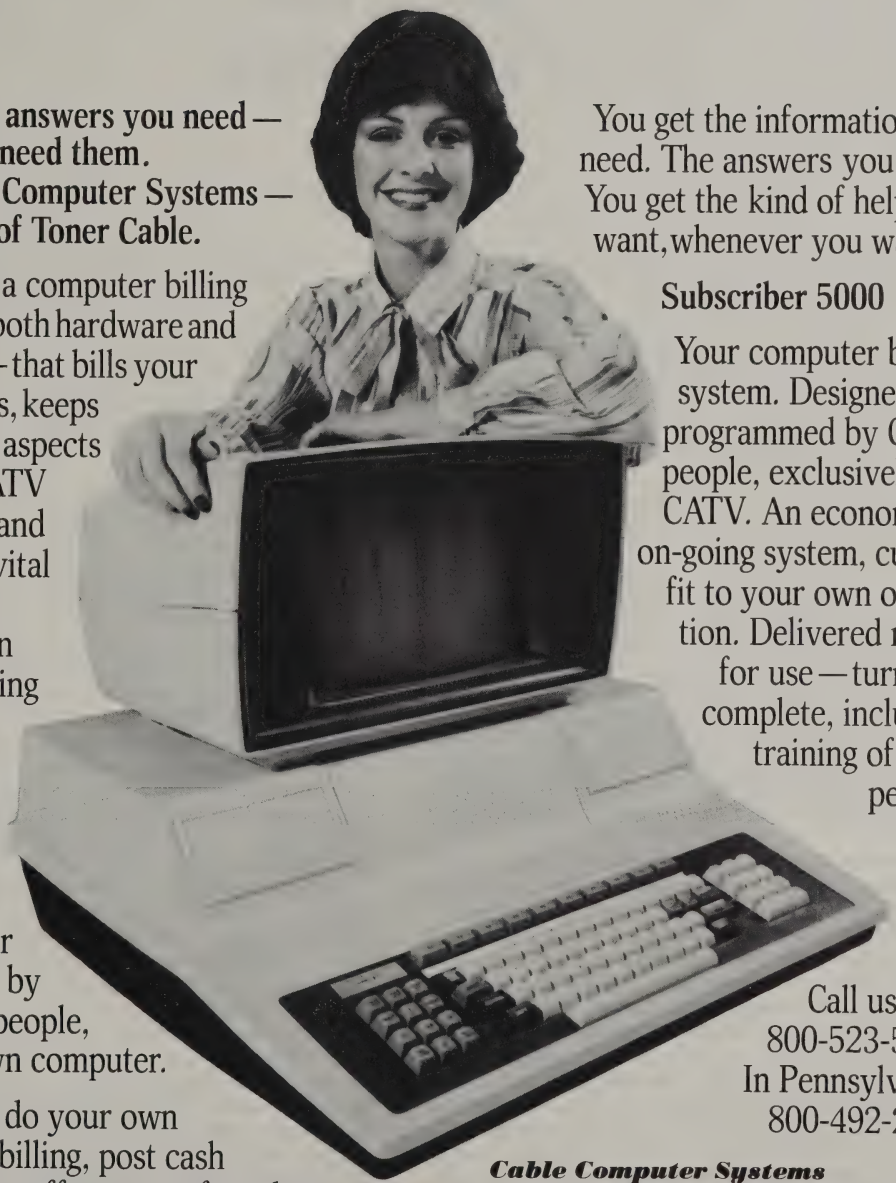

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Having Amplifier Noise? Maybe CATJ can help!

SYSTEM PLANNING II

In the September issue of CATJ, we discussed SYSTEM PLANNING and how noise poses one of the more common difficulties in CATV systems. The past article identified the four different sources of noise and discussed the problems created by man-made electrical noise, that originating on power lines fired by electrical sparks on electrical or combustible equipment and how to locate the source of the problem and attempt to correct it.

Another source, difficult to deal with and unpredictable, of course, is the atmospheric noise, a natural phenomena created by electrical discharges, such as lightning accompanying thunderstorms, will be discussed, in great detail, in a later issue by Dr. Rodney Bent, Atlantic Science Corporation, Indian Harbor Beach, Florida. The subject of Lightning and Power Surges is a tremendously fascinating and pertinent subject, and Dr. Bent's presentations have been highly acclaimed for their in-depth study and interesting approach to this mysterious quirks of Nature. You can look forward to seeing this material in an upcoming issue of CATJ; in fact, probably several issues as the material is lengthy and will take considerable space to cover it in the manner that has been requested.

But then, the remaining sources of noise can give you fits as they come from the equipment itself, but it's a relatively simple matter. NO amplifier is perfect, and it seems no one stocks perfect parts, and each of these problems adds a bit of noise.

When an engineer designs and builds an amplifier, he then must test it. They all use the same yardstick, and this is the amount of noise a 75 ohm resistor emits when it's heated to a certain temperature. A 75 ohm resistor is used because it's a 75 ohm system—the same principle applies to why a resistor emits noise as to why a light bulb emits light when it's heated by the electrical current. No, he doesn't plug the resistor into the wall—it's just about room temperature. Can't you imagine a resistor laying on the bench throwing out little bogs of noise??? This little bit of noise is his yardstick and he compares his amplifier to the resistor noise and says, "this amplifier has twice as much or some times as much noise!"

Because we use dB's all the time and they are only ratios, the engineer would then convert his temperature ratio to dB's also. If his amplifier had **twice** as much, he would list his amplifier as a 3 dB noise figure. Some of these ratios would be:

1.5 times as much - 1.76 dB
2 times as much - 3.01 dB
2.5 times as much - 3.98 dB
4 times as much - 6.02 dB
7 times as much - 8.45 dB
10 times as much - 10 dB

Now, here's how you can use this information. Suppose you had a pre-amp with a **3 dB noise figure** and **30 dB of gain.** The noise floor for TV signals is **-57 dB.** To this, we add the gain of our pre-amp or the new noise floor is **-27 dB.** Because our pre-amp has a **3 dB noise figure** itself, add that noise too; or now our noise floor is **-24 dB.** If we measure + 20 dB of signal out of the pre-amp, the signal to noise ratio is **44 dB.** If we had been using a pre-amp with **8 dB noise figure,** our signal to noise ratio would have been **39 dB.** This amplifier noise just keeps adding itself all the way through our plant, making a limit on how long our truck runs can be or how many amps deep the system can be.

Moral of the story? Use the lowest noise figures you can so they won't add too much noise. It's really **that** simple!!

Even with your earth station pre-amp, its **LNA** works the same way. Only instead of using dB of noise, engineers actually use the equivalent temperature of the resistor. It's a different value of resistor **(50 ohms),** and that's another area that could be explored—the use of a simple earth station pre-amp and antenna combinations.

But, back to principles involved, noise is the result of molecular motion in the antenna and

the receiving systems early amplifier stages, at random, called thermal agitation noise, and very small voltages are created by this molecular motion. Thermal agitation is dependent upon the **resistance component** of the **impendance** which the input of the receiver sees, and, of particular concern to television reception, the **bandwidth** of the receiving system.

We mentioned the **-57 dB** floor—how do you get that result? This is based on 75 ohms and a 6.0 MHz receiving system bandwidths as key factors in the equation; thus, even a noiseless TV front end would have a -57 dB noise floor, but irregularities of the current flow in the amplifier devices themselves would create **shot-effect noise** which is expressed as equivalent noise resistance, assuming for measurement purposes that the device is being referenced against a theoretical device with a noise figure of zero. With a **perfect** or **ideal** receiving system, no noise would be generated on its own, and the only noise contributed would come from the antenna system molecular motion and the atmosphere itself.

CATV equipment noise figures are a measurement of the equivalent noise voltages of the receiving equipment—pre-amplifier, signal processor, line amplifier, etc. In the CATV business, we are successful if our customers are happy, and those customers are pleased when we have good quality pictures, and **noise is their enemy.** Good quality pictures just don't happen—it is necessary that we maintain reasonably high ratios of signal and noise (signal-to-noise ratios). High receiving equipment noise figures work to a disadvantage; the higher the receiving unit noise figure, the greater our TV input signal voltage must be to produce good clean noise free pictures.

For these purposes for CATV, we have listed some projections of receiver noise figure equivalents for the more common CATV equipment on Table One. Remember that decibels are an expression of **power ratios** and noise voltage is really not an accurate term because of the random frequency response of the noise. Voltage suggests a specific measurement point, where noise voltage with a 6 MHz wide bandwidth is really a combination of **all** the noise in the bandwidth, which is one of the primary factors determining noise figures. While a 4.5 MHz wide bandwidth is needed to provide the wide modulation index of the TV video, we unfortunately adjust that to improve signal to noise ratios, because then we begin to cut out necessary parts of the modulated signal and then lose picture clarity. Bandwidth is not one of the things offering great possibilities for signal to noise improvement in your typical CATV equipment. However, wide band amplifiers **(all channel pre-amps)** have a much larger noise-factor than do single channel versions.

Actually, there's not much that system operators can do about the noise factor in equipment as it has its capabilities by its very design and you have to make the best of what equipment you have.

However, an understanding of how noise figure and system gain relate is helpful. Assume we have a -20 dBmv input signal to our first pre-amplifier. This is the average antenna level signal for our example system.

Based upon Table 2, the best we can get with a 17 dB noise figure front end is a 20 dB signal to noise ratio. A 17 dB front end would represent a UHF front end (u to V converter) with no RF amplifier.

Or, with an 11 dB noise figure front end, the best we can hope for is a 26 dB signal to noise ratio. An 11 dB front end would represent several of the VHF signal processing units available today.

TABLE ONE

This table sets forth the noise figure equivalents and signal level equivalents for common CATV equipment.

dB Level	Noise Figure	Microvolt Level
-57	0 dB	1.4 uV
-56	1 dB	1.6 uV
-55	2 dB	1.8 uV
-54	3 dB	2.0 uV
-53	4 dB	2.2 uV
-52	5 dB	2.5 uV
-51	6 dB	2.8 uV
-50	7 dB	3.2 uV
-49	8 dB	3.6 uV
-48	9 dB	4.0 uV
-47	10 dB	4.5 uV
-46	11 dB	5.0 uV
-45	12 dB	5.6 uV
-44	13 dB	6.3 uV
-43	14 dB	7.0 uV
-42	15 dB	8.0 uV
-41	16 dB	9.0 uV
-40	17 dB	10.0 uV

TABLE TWO

This table sets forth the **theoretical signal to noise ratios** experienced with a -20 dBmv (100 uV) input and various front end noise figures.

Noise Figure	Signal to Noise Ratio
17 dB	20 dB
16 dB	21 dB
15 dB	22 dB
14 dB	23 dB
13 dB	24 dB
12 dB	25 dB
11 dB	26 dB
10 dB	27 dB
9 dB	28 dB
8 dB	29 dB
7 dB	30 dB
6 dB	31 dB
5 dB	32 dB
4 dB	33 dB
3 dB	34 dB
2 dB	35 dB
1 dB	36 dB

With a 5 dB front end, the best we could hope for would be a 32 dB signal to noise ratio. A 5 dB front end would be a middle grade signal pre-amplifier.

With a 2.0 dB front end, the best we could hope for is a 35 dB signal to noise ratio (*almost* spec for 76.605 (9)). A 2 dB noise figure would represent a good grade VHF pre-amplifier.

In each case the input level remained the same (-20 dBmv or 100 uV); the only thing we changed

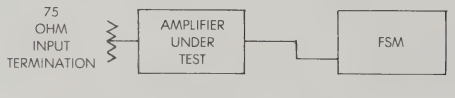


DIAGRAM ONE

was the noise (factor) contribution of the front end.

The front end is of course the first amplifier stage which the antenna delivered signal goes through.

A -20 dB signal level is too low for a processor directly. Most signal processing units must have at least -10 dB for the AGC system to function and even this is the bottom of the AGC range for such units. To be safe with almost any processor unit, and to allow for downward signal fades, the processor wants to have around +10 dBmv *on the average.*

To reach +10 dB from an average antenna level of -20 dB requires 30 dB of gain — *plus* — whatever the dB loss in the dB loss in the downline.

A signal processor with an 11 dB noise figure will still be showing *slight* grain in the picture with inputs as high as -11 dBmv (280 uV). This is a 35 dB signal to noise ratio for an 11 dB noise figure unit.

A -11 dB antenna level signal is pretty potent, but not high enough for most processor AGC's to function. Therefore, the normal approach is to add a pre-amplifier.

Since we only want to average +10 dB seemingly the pre-amp gain we require is on the order of 21 dB (the difference between -11 and +10). And with an average middle range VHF pre-amp 5.0 dB noise figure, this sounds like it might be the minimum spec for the pre-amp we are after. That is, 21 dB of gain and around 5.0 dB noise figure.

But is it?

An 11 dB noise figure with a -11 dB input signal was a 35 signal to noise ratio. Now a pre-amplifier is added ahead of the 11 dB noise figure processor. It has a 5 dB noise figure which means that the signal to noise ratio will be 11 minus 5 or 6 dB improved over the processor. That would be a 41 dB signal to noise ratio. With such a pre-amp installed our system signal to noise ratio for the channel becomes 41 dB at the input to the processor, while the processor now has an input voltage close to the +10 dBmv requirement.

The antenna level in our example has been tagged at -11 dB. This would be the average antenna level; on good days the signal is up some, and on bad days it is down some from that value. For each dB above -11 dB, the signal to noise ratio improves by a corresponding dB. And for each dB below -11 that the signal drops, the signal to noise goes down accordingly.

For example, if the signal fades down at the antenna to -20 dB, the following happens:

(1) The input to the pre-amp becomes -20 dB.

(2) With a 5 dB noise figure pre-amp this results in a signal to noise ratio of 32 dB. This is definitely a grainy (noisey) picture.

(3) The input to the processor has dropped from +10 dBmv (approximately) to +1 dBmv (approximately).

Checking the input to the processor, noting that the input level is around +1 dB, many operators would assume they were well up into the noise free region. *The grainy appearance to the picture would be a bit puzzling.*

It is not just signal voltage that determines signal to noise ratio however. In fact, signal voltage is secondary to noise voltage, *and the ratio between signal voltage and noise voltage.* And this ratio becomes cast in concrete for the entire CATV system at the input/output of the first amplifier unit on the channel in the system. With a fade down to -20 dBmv in our example, this ratio will never be any better than the 32 dB that is established at the output of the pre-amp. No amount of gain, nor having a lower amplifier noise figure later on in the system, will ever improve on this 32 dB best case ratio.

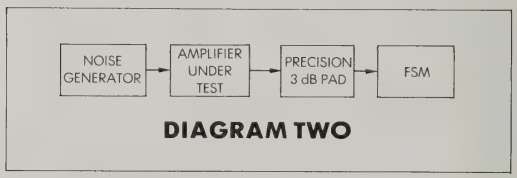


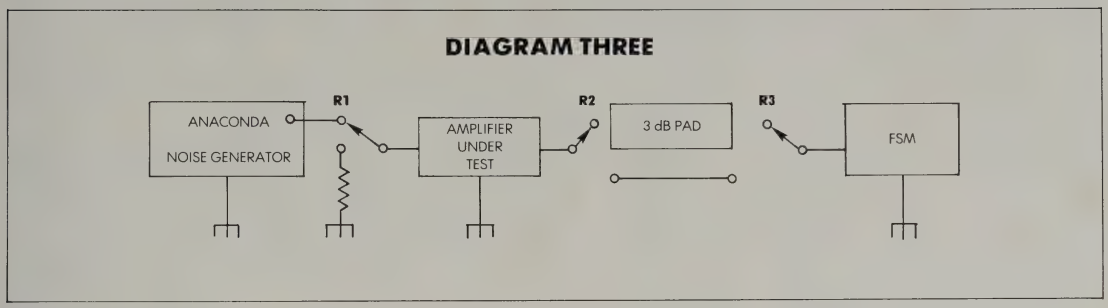
DIAGRAM TWO

Measuring Noise Figure

Most operators assume noise figure measurements are conducted in back rooms by super engineers with thousands of dollars in exotic measurement equipment. This can be so, but it is not necessary to have quite that amount of equipment or experience to do a creditable job.

Noise figure measurements are routinely made on signal pre-amplifiers by many manufacturers, but seldom on signal processors or line amplifying equipment.

All you really need is a reliable noise source, a calibrated pad, a FSM and some knowledge of what it is you are doing.



Reference is made to Diagram 1. The amplifier to be tested is terminated with its input impedance (75 ohms). The amplifier is powered and the FSM is tuned to the frequency of interest. In the case of a single channel amplifier, this is the visual carrier frequency.

Attenuation is removed from the internal pads of the FSM until you have some *convenient* scale reading. What you are seeing is the total output noise of the amplifier and its input termination.

Refer now to Diagram 2. The 3 dB precision pad cuts the output noise by 3 dB. The termination is replaced by a *metered noise source* (Noise Generator) and the pot control on the noise generator is advanced until the FSM reads the same noise level scale as you previously had with the termination in place.

The FSM is used merely as a calibrated volt meter, reading out not noise figure dB's but reference voltage scales. For example, if in the terminated mode you read 0 dB of scale (voltage) reading, in the test mode with the noise generator as a calibrated source replacing the 75 ohm terminator, you adjust the noise generator output level pot for the same "0 dB scale reading".

When the noise generator has been adjusted to produce the same noise output as the termination, you read the noise figure of the amplifier from the meter scale on the front of the noise generator. It meters calibrated plate current of the noise generating diode in the noise generator and is scaled in two ranges of 0-8 dB noise and 8-16 dB of noise.

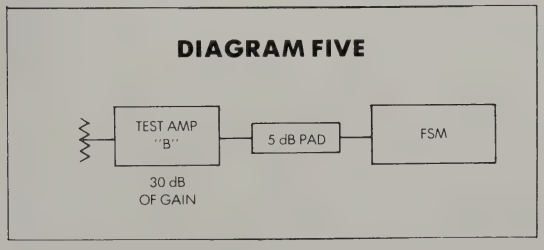
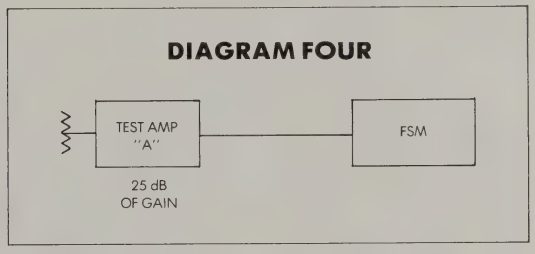


Diagram 3 shows how you might set up a permanent test station utilizing three 75 "F" fitting relays wired in parallel so that one switch takes you from a terminated mode to a noise measuring mode.

The only piece of equipment you really need, that you probably do not have, is the noise generator. It is not a very expensive unit to have around, and if you maintain any quantity of head end equipment, it is almost a must.

(Anyone who repairs their own lightning damaged pre-amplifiers should be advised that minute adjustments in the pre-amp after a FET or



bi-polar transistor is changed for a new one are absolutely necessary if you are going to get back the manufacturer's noise figure spec. Neutralized bi-polar devices are especially critical for noise figure optimizing, something you can only do with a noise figure test facility such as described here. And optimum noise figure and maximum gain are seldom found at the same tuning spot on any tuned amplifier stage.)

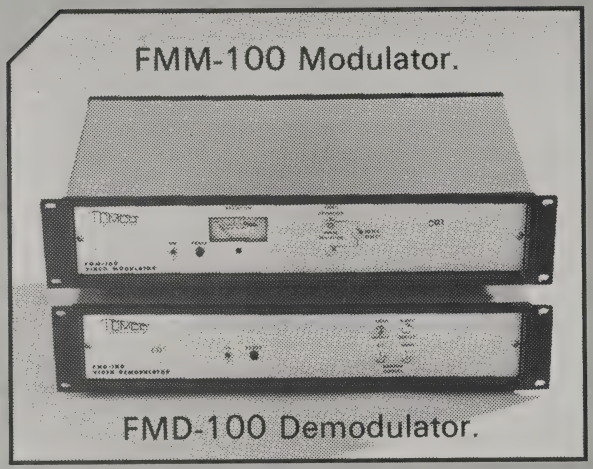
Comparing Noise Figures

If you cannot measure noise figure, you can usually compare noise figures for similar units. This will *not* give you an *absolute noise figure measurement* (even if you know accurately the noise figure of one unit), but it *will compare the relative noise* figure of two units.

See Diagram 4. A unit with a known gain of 25 dB is terminated, turned on, and the FSM is used to measure as accurately as possible the noise level reading on the desired frequency.

See Diagram 5. A second unit of known gain of 30 dB is terminated. The *difference* in gain between unit "A" and "B" (5 dB) is inserted as a pad in the output line of the second amp so we are comparing two units of the same voltage gain.

The place CATV operators keep coming to to keep going...



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The FSM is read directly for the reading difference between "A" and "B". If one unit gives a higher noise output than the other, relatively speaking (the gains of the two have been equalized) the lower reading noise output indicates a lower noise figure unit.

Note: Do not try to read the direct dB difference indicated by the FSM as an *absolute number* of dB's difference in noise figure of the two. And if you are measuring a single channel (pre) amplifier, rock the FSM tuning dial through the entire channel, noting the highest reading found within the desired channel range. Some units have peak noise outputs at points *other than* the visual carrier frequency.

Measuring System Noise

Adequate accuracy system signal to noise ratio measurements can be made to satisfy the requirements of 76.605 (a) (9) and 76.609 (e) by following the following procedure.

The rules require three measurement points within the system, one of which must be at or after the most distant (by cable and amplifiers) cable point in the system.

Signal to noise ratios are required only on those signals which are first received with-in their Grade "B" contours. This basically means any off-the-air signals you pick up at your head end, for which your head end is within the Grade B contour, or, any microwave delivered channel where the microwave pick-up point is located within the Grade B contour, must be measured for signal to noise ratio.

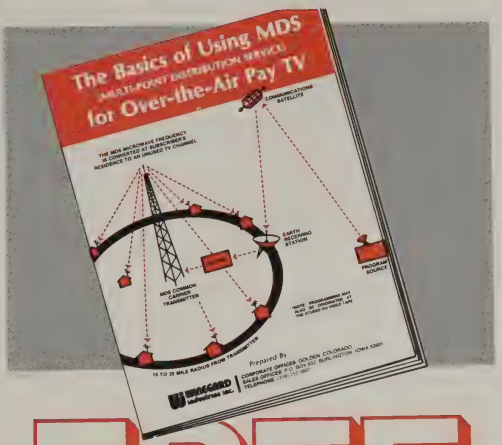
There are many sophisticated methods of measuring signal to noise on a plant. The FCC will, however, accept a pretty simple approach to this measurement.

In Diagram 6, a typical set of parameters are shown. The cable system channel input, at the signal processing unit, feeds through the combining network, down the trunk through trunk amplifiers, eventually through a bridge amplifier and then *through one or more* line extenders. For this example, we establish our measurement point at the *output* of the *last line extender* on this leg (this could well be the "deepest" extender in the plant).

We assume the line extender has a 20 dB back matched output test point; this gives us a relatively high level RF voltage reading for the visual carrier of the channel in question.

Between the output test point and the input to the FSM, we install a 1 dB step attenuator (a range of 0-61 dB is more than adequate). *All* attenuation is taken out of the FSM (i.e. it is operated in a wide open, or most sensitive mode) and attenuation is cranked into the 1 dB step attenuator until we have a convenient reference scale reading on the FSM. (Assume it reads 0 on the scale, or mid-scale).

Refer now to Diagram 7. The input to the signal processing unit is replaced with a 75 ohm terminator, to establish a loaded (matched) input



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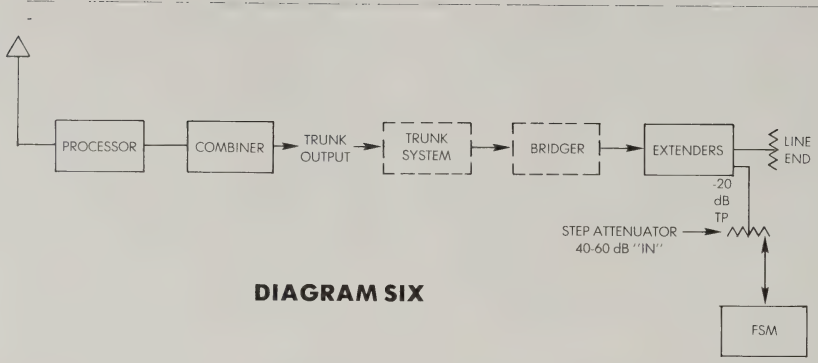

DIAGRAM SIX

condition, with a -57 dBmv noise level. Now the noise generated by the processor is the noise figure of the processor.

Back on the line extender in Diagram 6, we leave the FSM peaked (as in previous step) on the visual carrier (and do not touch the dial); start cranking attenuation *out* of the external 1 dB step attenuator until the FSM needle moves back up to the same (mid-scale) reference point where Diagram 6 adjustments were made.

The dB difference between the amount of attenuation *cranked in* for Diagram 6 measurements and taken *out* for Diagram 7 is the rough signal to noise ratio difference between your signal (Diagram 6) and your noise (Diagram 7).

Example: you had 50 dB of step attenuator cranked in to get your *reference scale reading* in Diagram 6. In Diagram 7, you had to take out 40 dB (leaving 10 dB) from the step attenuator to get back to the same reference scale reading point. The rough signal to noise ratio is 50-10 (40 dB); a signal to noise ratio of 40 dB.

Actually the true signal to noise ratio, in this type of comparative test is from 2 to 3 dB *worse* than the 40 dB we measured, because the typical FSM sees only 500-700 kHz of the 4.5 MHz wide TV (information) bandwidth. When we add in a correction number for expanding the bandwidth to the full TV channel, we lose a couple of dB of signal to noise ratio. You can be safe if you *take 3.0 dB from* what you measure, regardless of the FSM you are using.

While this test is required (76.605 (a) (9)), it pays to run the tests on all channels to assure yourself that you have future references for checking long term system signal quality.

Note: The Commission has never dealt directly with the question of *where* your system signal to noise ratio is truly established.

If you operate a processor with *no* preamplifier, the system signal to noise is established at the processor.

On the other hand, if you have one (or more series) pre-amps ahead of the processor, the system signal to noise is really established in the pre-amp and not the processor.

Thus you should *really* be terminating at the *input* to the pre-amp and not the input to the processor.

If your processor has a typical noise figure of 11 dB, and your pre-amp has a 2.0 dB noise figure, you system signal to noise ratio measurements will be (in this example) 9 dB *better* than you measure by terminating the processor.

76.605 (a) (9) requires that you maintain a 36 dB signal to noise ratio on Grade "B" contour (or better) signals. If you start coming up short of this minimum requirement with a terminated processor source, and you have a pre-amp ahead of the processor with a better noise figure, you should be terminating the pre-amp instead. Otherwise you will be short changing yourself

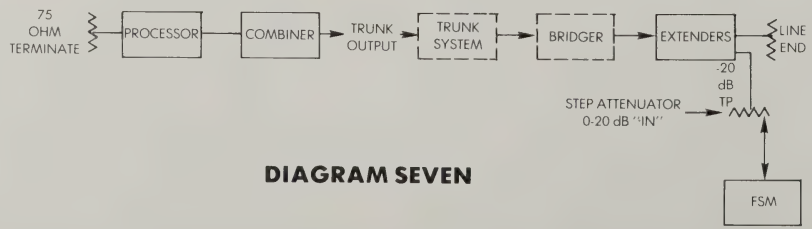

DIAGRAM SEVEN

the difference in noise figure improvement provided by the pre-amplifier.

We need to point out again that noise contributed by the equipment we use to amplify our signals is not as a rule the only noise with which we contend. Man-made noise factors are usually the limiting one to making commercial CATV use of signals that are quite weak, or co-channel gets us before the noise does so we are never really able to dig down into the noise limits of our system.

With the intentions of providing good quality pictures to our customers, it is incumbent on cable system operators to have signal to noise ratios in line so that this can be accomplished, regardless of the FCC rules governing cable systems. CATJ is preparing material that will be needed for your testing program, and as this is quite lengthy and involved, it will be run in subsequent issues so that you will have an opportunity to have this material as the end of 1979 rolls around.

The *Lightning and Power Surges* material will complete this series on noise sources, and you'll find it coming up soon!

CATJ Repeats...

CATJ is appreciative of the good response to our Reader Survey, and, as a result, we had many requests for repeats of articles from past issues. Those subscribers who have not been able to get all the back issues since the first issue of CATJ (May 1974) have been most encouraging for re-runs of some of the construction and antenna articles, as well as head-end receiving situations, system lay-out and design, and much, much more. We will be running some of these in subsequent issues, beginning with the one below. If you did not fill out your Reader Survey card from the July issue, we encourage you to take advantage of this opportunity in this issue, as we want to be able to furnish this timely and useful information to those who may have just recently joined us as a subscriber to CATJ.

Parts I & II, From April and May 1977

CARS BAND MICROWAVE PATH ALIGNMENT

by
John Schuble / William Ellis
Telesis Corporation
Evansville, Indiana
47714

Microwave path alignment (especially at CARS band) has been considered "black magic" or at best a tedious time consuming "art". And, it is just that, if it is not approached with a specific plan of attack in mind. Experience has shown that if alignment of even a relatively straight forward CARS band path is approached in a haphazard manner, many hours or even days may be consumed before acceptable results are obtained. Since contract tower personnel are quite expensive and not always readily available, it behooves the CARS band operator to achieve path alignment as rapidly as possible. **Although tower personnel** are skilled in their work, path alignment cannot be left to the contract tower crew, but must be supervised by a competent technician who knows what must be done and has a plan set out to accomplish the effort. During the past four years a technique has been developed which has proved itself on nearly 100 CARS band paths. It is a technique which is straight forward and lends itself to a step by step alignment procedure that can achieve optimum path alignment in the shortest period of time.

The approach does require good planning and many of the preparations can and must be

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completed before the tower crew is even on site. Before alignment is attempted the following information and equipment should be available:

1. **Path calculation sheet showing theoretical receive carrier level.**
2. Receiver AGC level vs. receive carrier level curve (for the receiver being used).
3. **Topographic maps with transmit and receive points located and a line representing the microwave path connecting the points.**
4. Field strength meter or large meter movement. (See procedure.)
5. **Angle finder.**
6. Three foot carpenter level.
7. **Two twenty foot pieces of nylon twine.**
8. Four two-way radios, sound powered telephones, etc.
9. **Two ground plane antennas.**
10. Video monitor.
11. **Compass**
12. Binoculars (optional).

After the necessary items have been assembled the following procedure should be read and throughly understood by the supervisor before the actual work is started.

PATH ALIGNMENT PROCEDURE

Path alignment is the process of adjusting transmitting and receiving antenna systems so that the maximum power is transferred between the transmit and receive site. It can involve direct radiators, reflectors, or both. If periscope systems are used at both the transmit and receive ends of the path, two antennas, two reflectors, and the antenna feedhorn polarizations will need adjustment. In some cases it may also be necessary to adjust the position of the antenna feedhorns. Where adjustable face reflectors are utilized, they may also require adjustment. Listed is a recommended sequence of events, which the authors have determined is the quickest and most reliable means of path alignment. Appropriate explanations are given with each step. The instructions apply to the typical microwave path shown in **figure 1.**

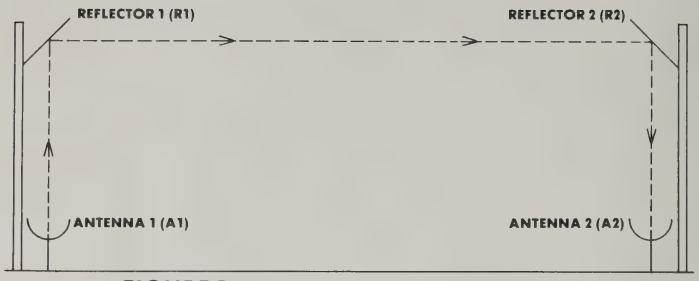

FIGURE 1 TYPICAL MICROWAVE PATH

Step 1: Appoint a Supervisor. Because the beamwidth of the transmitted energy will probably be less than 1°, the alignment of antenna system components is very critical at CARS band frequencies. Therefore, it is very important that only one component be moved at a time if there is to be hope of receiving a signal. As a result it is essential that **a** supervisor be appointed to direct adjustment of **each** antenna system component. Absolutely no adjustments should be attempted without his explicit instructions.

Step 2: Establish Communications. Appointing a supervisor and extablishing reliable communications will save hours or even days in the alignment process. The supervisor should have a direct communications link with all four points of adjustment. It is neither essential **nor desirable** that all four points communicate with each other. The supervisor will normally locate himself at the receive antenna (A2). From there he can communicate with R2 via sound powered telephones or hand held transceivers. He will communicate with A1 and R1 via hand held transceivers. (It may be necessary to install a temporary ground plane two-way antenna 75 to 100 feet on the receive tower.) It is possible to use telephones to communicate with A1, but this has the disadvantage of having to extent the telephone line at A1 to the area outside the building where the dish is located, or having to use two persons at A1 (one to man the telephone/relay information outside and one to adjust the dish). It may be necessary for the personnel at R1 and/or R2 to move their transceiver antenna from behind the reflector(s) before communications can be established.

Step 3: Level A1 and A2. If the dishes are located directly beneath the reflectors they may be set to a starting point with a three foot carpenter's level. This may be done by placing the carpenters level on the underside of the dish and adjusting the mounting legs until the dish is level. An angle finder, as shown in **figure 2,** will be used later to set the angle of the reflector. Angle finders are used by carpenters to set the "pitch" of roofs,

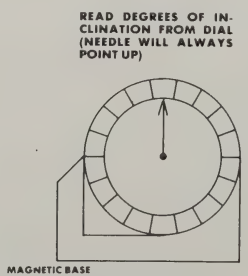

FIGURE 2 ANGLE FINDER

Assume that the dish must be moved away from the tower by distance "d" and the reflector is distance "h" above the dish. Calculate the tilt angles required for the dish and reflector. See Figure A

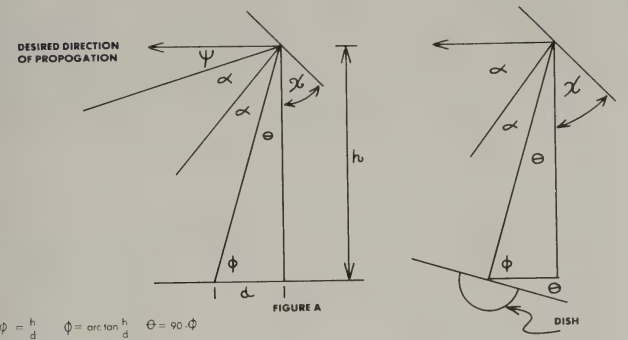

FIGURE A

$\tan \phi = \frac{h}{d}$ $\phi = \text{arc} \tan \frac{h}{d}$ $\theta = 90 - \phi$

Angle of incidence (α) = angle of reflection (α)
For proper reflection Ψ must not exist
We can therefore write $2\alpha + \theta = 90°$
and $\chi + \alpha + \theta + 90°$
Thus $2\alpha + \theta = \chi + \alpha + \theta$
or $\chi = \alpha$

The angle of the reflector must be set to the angle of incidence

The reflector angle is reduced by one half of the tilt angle of the dish
An example will demonstrate that fact. $2\alpha + \theta = 90°$
Assume $\theta = 20°$ |
$2\alpha = 70$
$\alpha = 35$ which is $\frac{\theta}{2}$ degrees less than 45°

FIGURE 3

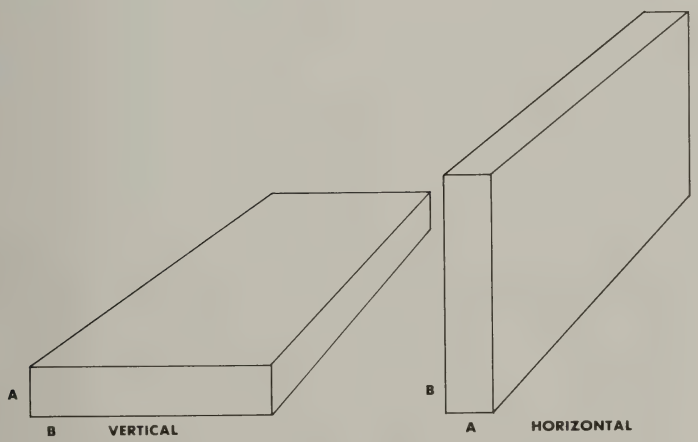

FIGURE 4 WAVEGUIDE POLARIZATION

etc., and can be purchased at most hardware stores. If the dish does not lie directly beneath the reflector, refer to **figure 3** to determine the tilt angle of the dish and reflector.

Step 4: Preset Polarization. Although waveguide is rectangular in shape, the mounting holes which allow two pieces of waveguide to be connected together may be arranged in a square configuration, which will allow the waveguide to be "crossed". If the waveguides are crossed, signal rejection will occur on the order of 30dB. It is therefore **imperative** that waveguide installation be undertaken with care **to avoid cross polarization.** Energy leaving the transmitting antenna system on one polarization must be received on the same polarization, just as if the transmitting and receiving antenna systems were two pieces of waveguide which had to be matched. The transmitting antenna polarization must also be set as specified by the station license (or construction permit, usually either vertical or horizontal).

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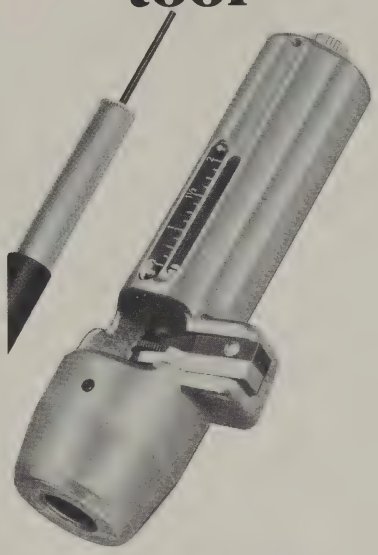

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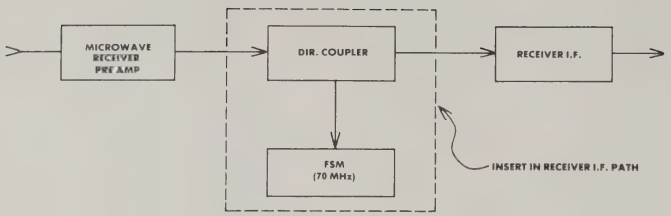

FIGURE 5 USE OF FSM TO MONITOR MICROWAVE RECEIVE LEVEL

position yourself behind the feedhorn and face the receive tower (underneath the dish). Turn the feedhorn until side B faces you **(figure 4).** For horizontal polarization, turn the feedhorn until side A faces you. You will only be able to turn the polarization about 120° with some antennas, because the feedhorn inside the dish employs guywires (spring loaded and adjustable) which are used to position and hold the feedhorn. The transmit polarization must remain in this position (as licensed) and the two ends (transmit and receive) are "matched" by adjusting the receive polarization only. As a starting point for the receive polarization, position the feedhorn just as you did the transmit feedhorn, by looking at the other tower and point Side B toward you for vertical polarization. This will usually be close to the final setting unless your antennas have circular feedhorns. With circular feedhorns the receive polarization may have to be turned anywhere from 0° to 90° to match the transmit polarization, since the energy may spiral in the circular feedhorns.

Step 5: Adjust Feedhorn. This step should be performed only by competent technicians who are qualified in antenna work, and should only be performed, or checked, when the technician has reason to suspect an antenna to be faulty. If new antennas are being used, this step may be skipped.

First, adjust the focal length of the feedhorn by moving it in or out of the dish; then adjust the spring tension on each of the feedhorn guywires until the feedhorn is centered in the dish.

Step 6 Preset R1. Using the angle finder described in Step 3, adjust the reflector to 45°. If A1 has been set to any angle other than 0° (level), R1 must be set by 1/2 of this difference. For example, if the dish was tilted in toward the tower from level by 20°, the reflector must be raised from 45° by 10° (see figure 3). Set R1 on azimuth (aimed toward the receive tower). Use topographical maps and landmarks, pocket compass and calculated azimuth, and visual sighting of the receive tower to set R1 on azimuth. Be precise with the setting of R1, since **it** is the component most likely to prevent signal reception during the first alignment attempt of R2.

Verify that the face of R1 is flat by stretching a piece of string across it's surface. (Some reflectors have an option whereby adjustments are available to curve the face of the reflector to achieve more gain as a result of a specific distance between A1 and R1 and a specific size of A1 and R1.)

Step 7: Set up to monitor received signal strength. The receiver AGC meter can be read to obtain an indication of the strength of the received signal, but **this method** does **not** provide the needed sensitivity for either picking up a signal **initially** or for determining **small increments** of change in the signal level. A video monitor **connected to the video output terminal of the receiver** will enable an observer to detect signals which would be too weak to cause a indication on the AGC meter. Be sure to connect the video monitor to an **unsquelched output** of the receiver.

Another method of observing the strength of the received signal is to monitor the noise level out of the receiver. This method is preferable to the AGC meter, because of it's better sensitivity; however, it is seldom used with CARS band microwave when field strength meters are available. Shown in **figure 5** is a configuration utilizing a field strength meter as an indicator of received signal strength. The method shown has the advantages of good sensitivity and good portability. The field strength meter can be taken outside to A2 for purposes of adjusting A2, since it is battery operated and uses 75 ohm cable commonly found at CATV systems to deliver the signal to the meter. **The meter must be tuned to 70 MHz,** therefore a signal must be detected **with the video monitor before** the FSM can be tuned and used.

One other method used is to simply purchase a large meter movement and temporarily wire it in the place of the smaller AGC meter. This will provide increased sensitivity and portability, since the meter can be extended to A2 with any suitable pair of wires.

Step 8: Verify and monitor transmitter operation.

Step 9: Pan R2 to receive signal. The most common error made when aligning reflectors is demonstrated in figure 6. The main lobe of the reflector is shown as a small circle with side lobes shown as a larger circle. It is easily seen that

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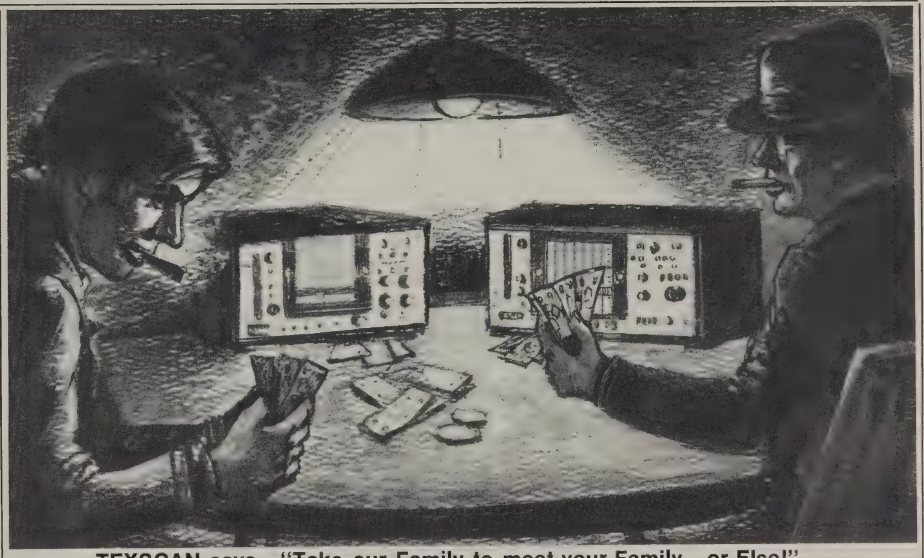

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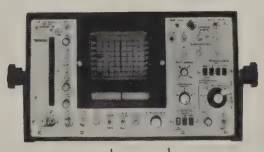
Wanted for $1900



VSM-5A

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The VSM-5A is wanted for complete spectrum analysis requiring phase lock and narrow resolution bandwidths. This instrument is capable of all FCC proof of performance measurements except system flatness.

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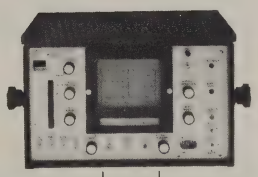

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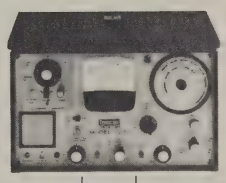

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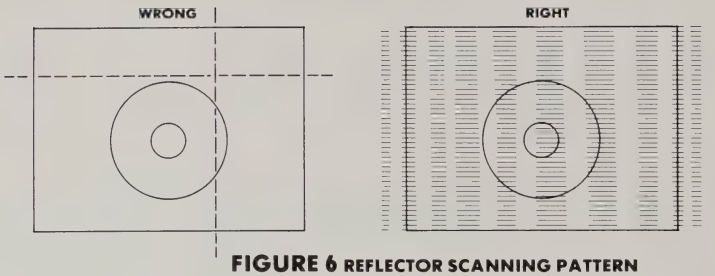

FIGURE 6 REFLECTOR SCANNING PATTERN

mere vertical and horizontal adjustments will not necessarily cross the main lobe. The **only way** to insure that you have looked at all points on the reflector is to scan it as demonstrated.

Set the reflector elevation at approximately **49°** and move it horizontally from one side to the other, and note what signal levels are received. Then change the vertical setting to **48.5°** and again perform a horizontal pan. **Continue making horizontal pans at half degree increments down to 41°.** (Use the angle finder described in step 3.) Return the reflector to the point where the highest level of signal was received.

If no signal is received, return to Step 6.

Step 10: Adjust A2. Most antennas are mounted on 3 or 4 adjustable legs which rest on a pylon or outrigger. Adjust **each** leg sequentially for maximum received signal, **after polarization has been rotated for maximum signal.** Alignment will **not** be precise **if** the polarization is **changed after** the dish has been adjusted, because polarization changes may slightly alter the pattern of the antenna. After polarization and dish adjustments have been performed, repeat the operation to correct any imperfections which result from interaction of the adjustments.

Step 11: Pan R1. Adjust for maximum received signal as in Step 9. The transmit antenna system is independent of the receive antenna system. No adjustment performed in this step or Step 12 below, will change the settings of Step 9 or Step 10.

Step 12: Adjust A1. Follow procedure described in Step 10.

This completes the steps required to align the antenna of the typical microwave hop described. In the event that a signal cannot be received, the problem may be one of the common causes listed below:

1. **Insensitive receiver.**
2. Low transmitter power.
3. **R1 not pre-set properly.**
4. Moisture or obstruction in waveguide. (Loss can be checked with transmitter or signal generator, and power meter).
5. **Crossed waveguide in path.** (Also, a **choke-type connector** connected **directly** with another **choke-type connector** can cause appreciable signal loss.)
6. Receive polarization improperly pre-set.
7. **Obstacle in path, not reported on field survey.**
8. Defective antenna.

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Microwave Path Alignment—Part II

Microwave path engineering includes a number of steps that must be taken to arrive at the desired final result. The dollar conscious cable operator who is willing to expend his own energy can, with proper guidance, undertake certain of these efforts himself and achieve significant monitary savings. One of these efforts is the "field survey". A field survey is just what it sounds like; an outdoor exercise to verify paper path engineering.

Equipment manufacturers are generally willing to supply a significant amount of the path engineering at no cost (except for the purchase of their radio equipment). But they will not and should not be expected to complete a field survey. Although a field survey can be contracted to a qualified microwave engineering company, it is costly, averaging some $1500 for a simple relatively flat terrain path.

Before spending that kind of money for a mere paper report, the prospective microwave user might ask if the field survey is really necessary. The answer to that question is that a field survey is an insurance policy. It insures that the topographic maps were correct and that no new path blocking structures have been constructed since the topo maps were last up dated, (sometimes many years ago).

What is risk-to-premium-ratio of the field survey "insurance"? That figure may be determined by considering the implications of a blocked path. If the transmit or receive tower cannot be increased in height to clear the obstruction, a new transmit site would probably be needed. A new site would involve:

1. New path engineering.
2. **New FAA clearances.**
3. New zoning variance.
4. **New FCC construction permits.**
5. Removal and replacement of tower and buildings.
6. **Restoration of original tower site.**

Faced with these possibilites, the field survey "insurance premium" looks very inexpensive. But in this case there **is** a way to have the "insurance" at a very very small premium. That is by conducting your own field survey. Impossible? No! It's a matter of following some straightforward rules and interpreting the results.

How to Proceed.

First of all obtain topographic maps of the entire path. Maps and indexes can be procured from the "USGS" at the addresses given, and used by any individual to report the necessary data.

For maps East of the Mississippi

Eastern Region Map Distribution
U.S. Geological Survey
1200 South Eads Street
Arlington, VA 22202

For maps West of the Mississippi

Branch of Distribution
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U.S. Geological Survey
Federal Center, Building 41
Denver, CO 80225

The "Surveyor" uses transparent tape to connect the necessary maps together. The transmit and receive sites are then marked on the maps, and a straight line is drawn connecting the two sites. The surveyor can then use the maps to physically locate himself at all points along the path to investigate possible obstructions or other problems, and to verify the information shown on the preliminary terrain profile (usually supplied by the radio manufacturer). Information which can be derived from the maps includes site co-ordinates, range, township and section (for legal description of land), terrain elevations at time map was published, locations of bodies of water (potential reflective surface), locations of airports, schools, churches and other landmarks, locations of surveying benchmarks, marshland areas, locations of railroads, highways, bridges, cemetaries, telephone and power line towers, radio towers, buried pipelines, as well as many other items of possible interest. Additional information concerning maps and the symbols used is received with each group of maps from the USGS, which is color coded. (Blue for water, pink for urban areas, etc.)

A. **Equipment Needed.**
In addition to topo maps and a suitable vehicle, the surveyor will require a good set of binoculars, a pocket compass, 100' measuring tape, and an inclinometer (see diagram 1). The inclinometer is used primarily to measure the heights of objects from the ground and can be purchased for a few dollars.

The user points the inclinometer into the air at 45° and toward the top of the object to be measured (See diagram 2). If it points above the object, the user moves **closer**. If it points below the object, the user moves **farther away**. When the inclinometer's air bubble in the level is centered, and when at the same time the inclinometer is aimed at the top of the object to be measured, the user has created a right triangle, and he knows that the **distance from the inclinometer to the bottom of the object is equal to the height of the object.** A tape measure is then used to measure the height of the object by measuring the distance on the ground from the inclinometer to the bottom of the object. (NOTE: The **height of the user** must be **added to** the **height of the object,** since the inclinometer is actually at eye level, rather

than ground level.)

B. **What to check.**
In addition to reporting height and nature of obstructions in a proposed microwave path, the surveyor should, as a minimum, include the following items:

1. **Are tower sites marked correctly on the topo maps?** (This data must be used to eventually verify that the preliminary profile was prepared using the proper site co-ordinates.)
2. **Are there any obstructions** along the path which are greater in height than the tree heights drawn on the preliminary terrain profile?
   a. Are there any obstructions to the side of the path **within 500'?** (The actual clearance requirements for the sides of the path are as in the path; however, the 500' number provides some tolerance for the map and user. If nothing is reported within 500', adequate clearance exists for CARS band paths of up to 35 miles. If an object is reported to be within 500' of the path, an engineer and professional surveyor should be employed to determine the exact clearance requirement and to make precise measurements of the object in question.)
3. **If the site** has an existing building, is there room for the microwave racks, batteries, chargers, etc?
4. Report condition and type of tower(s) if existing, as well as available vertical space on the tower for locating microwave antennas. Also report other antennas on the tower which might block or impair the signal of a **"periscope"** shot (reflector).
5. Are there any known **high power radar sites** anywhere in the vicinity?
6. Is there **any other** microwave operating **in the CARS band** of 12.7 to 12.95 GHz? This will often be either Cable TV micro-

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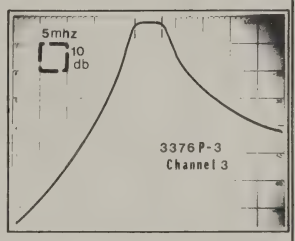

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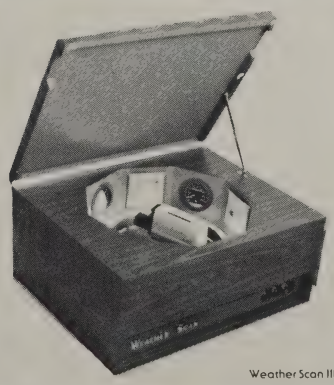
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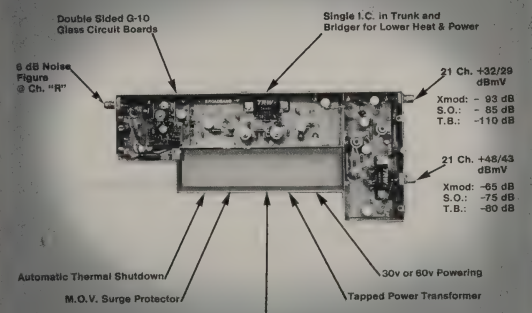
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INCLINOMETER

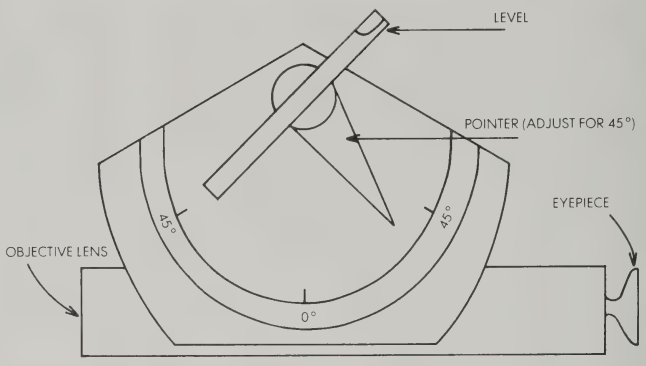

DIAGRAM 1

MEASURING THE HEIGHT OF AN OBJECT WITH AN INCLINOMETER

A=B when angle X is 45°. Therefore total height of tree is B+C (distance from ground to observer's eye level)

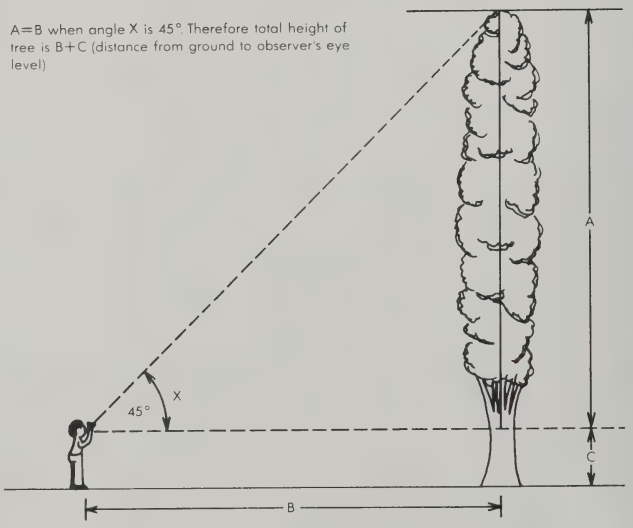

DIAGRAM 2

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wave or television stations' studio to transmitter microwave in the area. Most sites can be eliminated as suspected users of CARS band microwave by checking the **physical size** of the **waveguide** from outside the building, making it unnecessary to contact the owner and/or gain access to the building. An **alternative** to physically checking for CARS microwave is to employ the services of a company with computerized records of all licensed microwave sites.

7. Are there any **flat surfaces** to the **side** of the path whose angle would result in a **second signal being received** via a reflection from this surface? Round water tower surfaces, unless they are unusually large, may be ignored. Tall gas station signs can be a problem, particularly if they are continuously rotating.
8. Are there suitable roads existing to the sites, which will allow access to the sites during **all seasons** and during inclement weather?
9. Report the distance to the nearest commercial power lines.
10. Does the site present an obvious **zoning** difficulty? For example, is it in an exclusive residential area, or an area where individuals could be expected to strongly object to the construction?
11. If the site is to be used as a CATV headend pick-up point, report the location and power of FM transmitters, and potential sources of electrical interference. **If** the site is to be used **solely for** CARS band microwave, FM transmitters and other broadcast transmitters, as well as sources of electrical interference such as commercial power lines, **may be** ignored.
12. Report bodies of water on or near path.
13. Report the general condition of the tower site(s). For example, is the site heavily wooded, making construction difficult and/or more expensive than normal?
14. Does the geology of the site present an obvious problem? For example, is the terrain rocky, requiring dynamite for anchor holes, tower base, etc. (This **can** present a **grounding** problem also, if rods can't be driven into the ground.)
15. Report any other item specifically requested by the engineer in charge.

C. **Some additional points of interest.**

1. It is tempting to bypass the field survey by **"flashing the path". One end** of the path **emits** a light source of considerable intensity, while an observer at the **opposite end** of the path reports that he can **see** the light. This is **an inconclusive means** of determining path clearance and should **not** be employed, since it makes no allowance for beam bending or fresnel zone

Continued On Page 48

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TVRO Earth Station RF Parameters assessed without expensive test gear — continued.

Steve J. Birkill On Experimental Earth Terminals

Steve J. Birkill
Real-World Technology
128 Cross House Road
Grenoside, Sheffield S30 3RX England

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Last month I described a method for estimating system noise temperature fairly accurately using only a step attenuator and signal level meter. This time we look at a way of measuring figure of merit, G/T, directly, using solar noise as our signal source.

The sun, being rather a hot body, is a powerful source of radio noise over a wide band of frequencies. If we plot the flux density arriving at the earth's surface during a period of low solar activity, a graph similar to diagram one is obtained. We can see that flux density rises rapidly with frequency (the graph here is plotted on log-log axes) from 90 x 10^{-22}W/m²/Hz at 4 GHz to 350 x 10^{-22}W/m²/Hz at 12 GHz.

For the moment we shall assume that the sun looks like a point source. So the more we increase antenna aperture, or gain, at a given frequency, the more noise power will we intercept. Antenna gain is given by

$$G = \frac{4\pi A\eta}{\lambda 2}$$

where A is the projected area of a reflector type antenna as seen by the signal, and n is the aperture efficiency expressed as a decimal. For a paraboloid dish of circular aperture,

$$A = \frac{\pi D^2}{4}$$

D being the diameter (aperture) of the dish, and n lying between 0.5 and 0.7, dependent on feed design.

Of course, wavelength λ must be expressed in the same kind of units as D.

The gain thus obtained is a numerical quantity indicating the increase in effective power the antenna can radiate in a given direction compared with a hypothetical isotropic source. And the same gain applies when receiving. Gain figures are commonly (and conveniently) expressed in dB, but for now consider gain just as this numerical ratio. Then for a given power flux density which we shall call S, the power delivered at the antenna feed horn flange is

$$\frac{S \times A\eta}{2} \text{ W/Hz}$$

(since we can only look at one sense of polarization at a time, giving half the power), A n being the **effective** area of the antenna. Now the quantity of interest to us is the antenna noise temperature resulting from this flux S, or the temperature to which a source resistor at the antenna flange would need to be raised to generate the same noise power. This power is given by kT_sB, where T_s is the antenna noise temperature in °K, B is the bandwidth in which the noise is specified or measured (in this case 1 Hz) and k is Boltzmann's constant, 1.38 x 10^{-23} W/°K - Hz. So we can calculate the antenna noise temperature in terms of solar flux density and antenna gain, since

$$kT_sB = \frac{SA\eta}{2}$$

$$= \frac{SG\lambda^2}{2\pi}$$

$$\text{so } T_s = \frac{SG\lambda^2}{2\pi k} \qquad (B = 1)$$

Putting values to the constants, this gives

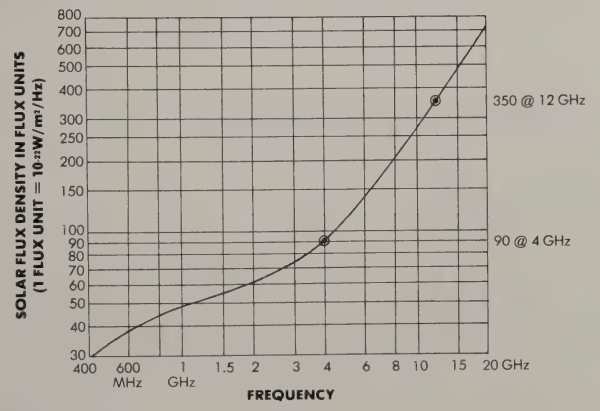
$$T_s = \frac{SG\lambda^2}{3.47} \times 10^{22}$$

Going back at this point to diagram 1, let us take the indicated values for S at 4 GHz and 12 GHz, and plot a graph of T_s against G (now converted to dB, hence the logarithmic scale) for the two values of λ corresponding to the frequencies of interest.

What all this means is that if we know the value of solar flux density applying at the time of measurement, and if it is valid to assume the sun to be a point source at infinite distance, then we can relate antenna noise temperature to antenna gain, and thus by an operation similar to that described last month relate system noise temperature and antenna gain, deriving G/T. This is because the total noise measured in the receiver when aligned on the sun is due to T_s (solar noise, as defined above) plus T_R (receiving system noise, including antenna noise and sky noise. When the antenna is moved off the sun, receiver noise is due only to T_R. (Note that I have employed different definitions of these sources of noise

DIAGRAM 1

VARIATION OF SOLAR FLUX DENSITY (QUIET SUN) WITH FREQUENCY.



If you were a pioneer in installing and licensing your TVRO, your three-year license will need to be renewed very soon!!

DON'T FORGET TO RENEW YOUR TVRO LICENSE!

As a service to CATA members and all other readers of CATJ, we want to remind you that licenses for Television Receive Only Earth Terminals are for **three-year** periods. Since it was about three years ago now that the FCC started to license TVRO's for cable systems, now is the time for the pioneers to start looking into getting renewals of their licenses. To make your job easier, we are printing the FCC form required for renewals. It is a simple one, and you can do it yourself—no need to pay lawyers when you can take care of this one yourself!

The FCC advises us that technically you only have to be sure they get the renewal application **prior** to the expiration date of your license—the expiration date is printed right on the license that the FCC sent you when you first got approval. However, for their convenience, they would prefer that you file the renewal application **between 30 and 60 days BEFORE your current license expires.** Also, if you are going to send it in early, the FCC staff asks that you **NOT** send it in **earlier than 90 days** before the expiration date.

The form speaks for itself, and takes only a few minutes to fill out. You need to pay careful attention to the instructions in regard to furnishing **TWO** copies of the application form to the FCC. Also, **do not** copy it after signing the original—there should be an **ORIGINAL signature on both copies—**that is, don't sign it and then duplicate it. Sign it **after** you duplicate it, and be sure to keep a copy for your own files. Also pay particular attention to the name of the applicant being the **same** as that on the current license.

There is no filing fee. Send the two forms to:

Office of the Secretary
Federal Communications Commission
Washington, D.C. 20554

That's all there is to it—mark it on your calendar and do it without fail! As a convenience to our readers, the tear-out form opposite this reminder is the official form to be used.

FCC Form 405
February 1977

Form Approved
O.M.B. No. 52-R0048

Applicant Should Not Use This Block

File No.:

Call Sign

Service:

Class:

Federal Communications Commission
Washington, D. C. 20554

APPLICATION FOR RENEWAL OF RADIO STATION LICENSE IN SPECIFIED SERVICES

Specified Services
(FCC Rules Part 5, Part 21, Part 23, Part 25)

INSTRUCTIONS:

1. Submit TWO COPIES direct to the Federal Communications Commission, Washington, D. C. 20554. (Only one copy is required for application under Part 5 of FCC Rules.)
2. Name of applicant must be identical with that shown on current license.

1. Name of Applicant: *(See Instruction 2)*

2. Address of Applicant:

3. Application is for renewal of license in exact conformity with the existing license as specified below:

File No. ---------- Date ---------- Call ----------
Location ---------- Nature of service ----------
Class of station ---------- Expiration date ----------

4. Note any changes such as discontinuance of use of a frequency, or of a type of emission or of a transmitter; correction of serial number of a transmitter; or any minor change in a transmitter not requiring a construction permit, which have been made since the last application covering this station was filed:

---

5. *(a)* If applicant is a partnership, state whether there has been any change of members in the partnership since the date of last application to the Commission, and indicate such change, if any:

(b) If applicant is a corporation, state whether corporate charter has been amended since date of last filing of copy of same with the Commission, and submit a certified copy of any such change if same has not already been filed:

(c) If applicant is a corporation, state whether there has been any change in stock ownership which results in a transfer of control of the corporation:

(d) If any officer or director of the corporation is an alien give respective name(s), citizenship, official title(s), and dates of appointment or election:

(over)

6. Except as noted on this form, applicant represents that there has been no change in applicant's organization and that there has been no transfer of control or changes in the applicant's relation to the station, financial responsibility, or in the equipment authorized to be used by the station; that applicant's most recent application embodying this information (file----------, date ----------) is to be considered as a part of this application, and the truth of the statements therein contained is hereby reaffirmed. Note here any further exceptions, not already covered in questions 4 and 5:

---

7. Applicant, if a common carrier, represents that the effective tariffs of applicant, filed for this station, identified by FCC numbers, are as follows:

---

8. Applicant waives any claim to the use of any particular frequency or of the ether as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise, and requests a station license in accordance with this application. Applicant acknowledges that all attached exhibits are a material part hereof.

CERTIFICATION

I certify that the statements in this application are true, complete and correct to the best of my knowledge and belief, and are made in good faith.

Signed and dated this ---------- day of ----------, 19 -------.

Name of Applicant (must correspond with Item 1)

WILLFUL FALSE STATEMENTS MADE ON THIS FORM ARE PUNISHABLE BY FINE AND IMPRISONMENT. U. S. CODE, TITLE 18, SECTION 1001.

By ----------
(Signature)

Title ----------
(Designate appropriate classification below)

- ☐ Individual Applicant
- ☐ Member of Applicant Partnership
- ☐ Officer of Applicant Corporation or Association
- ☐ Official of Governmental Entity Competent under the Jurisdiction to Sign for the Applicant

NOTICE TO INDIVIDUALS REQUIRED BY THE PRIVACY ACT

Personal information requested through this form is authorized by the Communications Act of 1934, as amended, and specifically by Section 308 therein. The information will be used by Federal Communications Commission staff to determine eligibility for issuing authorizations in the use of frequency spectrum and to effect the provisions of regulatory responsibilities rendered the Commission by the Act. Failure to provide all requested information will delay the processing of the application. Information requested by this form will be available to the public.

THE FOREGOING NOTICE IS REQUIRED BY THE PRIVACY ACT OF 1974, P.L. 93-579, DECEMBER 31, 1974, 5 U.S.C. 552a (e)(3).

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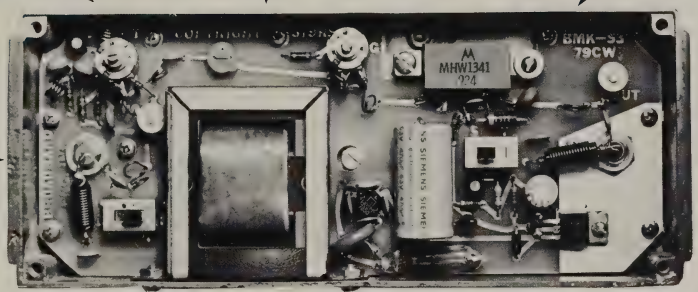

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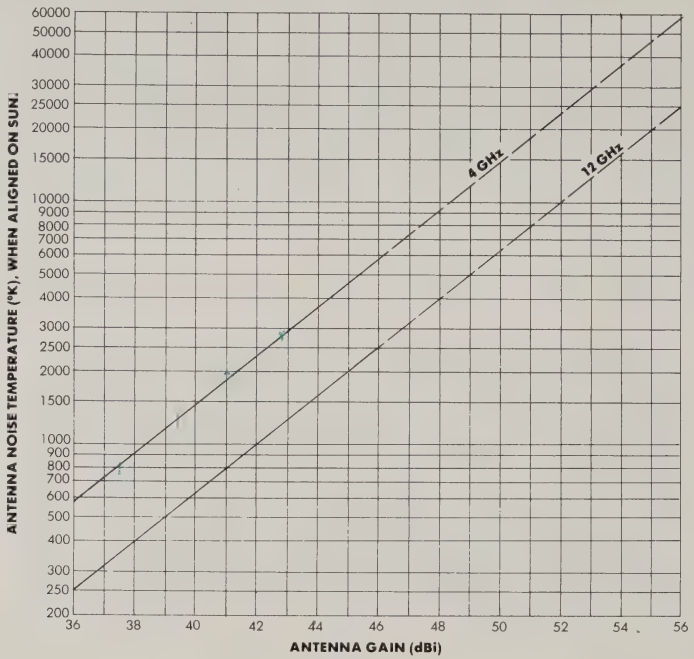
DIAGRAM 2

ANTENNA NOISE TEMPERATURE DUE TO QUIET SUN, AT 4 GHz AND 12 GHz, NEGLECTING EFFECT OF BEAMWIDTH



temperature compared with last month, purely for convenience.) So by measuring the change in receiver noise level between the 'sun on beam' and 'sun off beam' conditions, we can calculate G/T, as follows:

This 'change' or power ratio, we shall call Y.

$$Y = \frac{T_R + T_S}{T_R} = 1 + \frac{T_S}{T_R}$$

But we know that

$$T_S = \frac{SG\lambda^2}{3.47} \times 10^{22}$$

$$= \frac{90 \times 10^{-22} \times 0.075^2 \times 10^{22} \times G}{3.47}$$

(at 4 GHz, $\lambda = 0.075$ meters)

$$= 0.146\ G$$

Substituting, $Y = 1 + \frac{0.146\ G}{T_R}$

But T_R, the receiving system noise temperature, is the 'T' in 'G/T'. So we can straightaway say that

$$\text{'G/T'} = \frac{Y - 1}{0.146}$$

Since 'G/T' is normally expressed in dB/°K, and Y is conveniently measured in dB (diagram 3), a logarithmic version of the above is required, as follows:

$$\text{G/T (dB)} = 10 \log \left(\frac{\text{antilog} \left[\frac{Y(\text{dB})}{10} \right] - 1}{0.146} \right)$$

This applies at 4 GHz and rests on the assumptions made so far. The corresponding formula for 12 GHz is:

$$\text{G/T (dB)} = 10 \log \left(\frac{\text{antilog} \left[\frac{Y(\text{dB})}{10} \right] - 1}{0.0631} \right)$$

Now, what about those assumptions? Most important consideration, especially at the time of writing, is the fact that the sun isn't 'quiet'. In fact it is reaching the peak of its activity. The nearer in time to the 'sunspot maximum', which occurs approximately every eleven years, the greater is the value of solar flux, and the greater the amplitude of the day-to-day fluctuations in flux density. The standard measurement of solar flux density is made at local noon by the Herzberg Institute, Ottawa, Canada, at a frequency of 2.8 GHz. Information is distributed by the National Oceanic and Atmospheric Administration (NOAA), Boulder, Colorado, and broadcast by WWV at 18 minutes past the hour (each hour) on the following day. This 2.8 GHz figure has a minimum value of around 65 flux units (10^{-22}W/m²/Hz) when the sun is 'quiet'. Highest recorded value occurred during the 1947 solar maximum, exceeding 450 solar flux units. A call to NOAA or to the National Bureau of Standards a few days after the measurement should establish the current value of the 2.8 GHz solar flux. Or obtain part 1 (monthly) of Solar-Geophysical Data, published by the Department of Commerce, Boulder, Colorado. Solar flux (diagram one) varies approximately as the square root of frequency ratio (above 1.5 GHz), so the 4- and 12-GHz figures can be derived from the 2.8 GHz standard frequency measurement. Or just apply the appropriate vertical axis shift to the diagram.

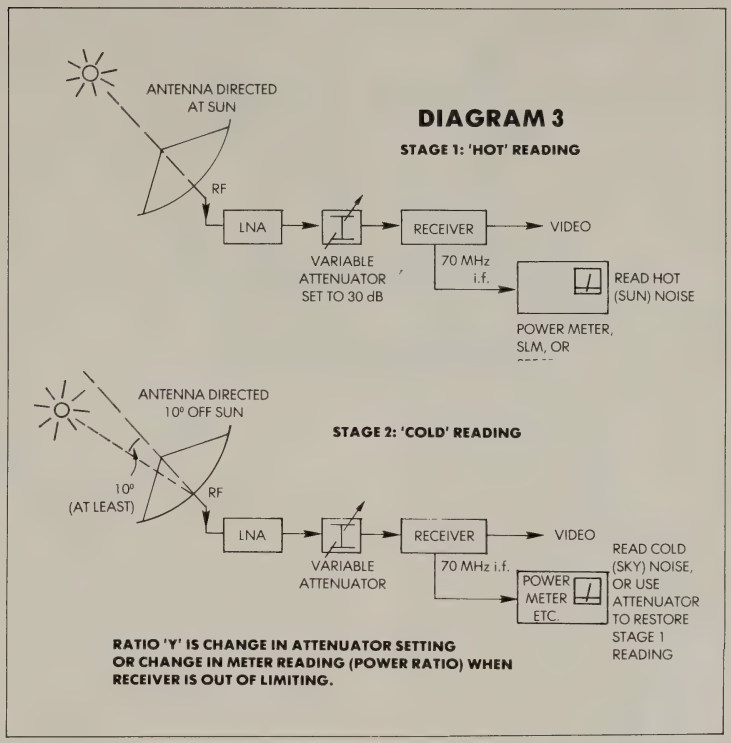
Second necessary assumption is that the sun is at an infinite distance. Well, this is a valid assumption, as will be seen if an attempt is made to calculate the angle between rays arriving at opposite edges of our fifteen foot or so aperture, from a source at 93 million miles distance. It's quite a small angle.

The third assumption involves a different angle, that subtended by the sun at our antenna. Now due to the size of the sun, this is not negligibly small but is about 0.5 degree. With a small

(low gain) antenna this can be regarded as a point source, and diagram 2 will apply, as will the formulae derived from it, adjusted as necessary for solar flux variations. But as we increase antenna gain, so beamwidth decreases, until it becomes comparable with the sun's radio diameter. Any increase of gain (decrease of beamwidth) beyond this will fail to give a corresponding gain of received noise power, as our beam is now seeing less than the full disc of the sun. So the G/T figure derived as above will be in error, indicating a lower figure than it should. So we should perhaps apply a correction to the right-hand half of diagram 2, to reduce the slope of the 4 GHz and 12 GHz lines, leveling them off above a gain of 50 dB, corresponding to a 3 dB (half-power) beamwidth of a half degree. We can in fact regard the diagram as accurate only up to around one degree beamwidth, that is a gain of about 45 dB. At 50 dB gain the error will be about 1 dB.

So how to use this method for higher gain antenna systems? Ideally we would like to have a source of constant and known flux density, appearing to be a true point source at an infinite distance. And this is exactly what is used for calibrating the really large earth stations, such as those used by Intelsat.

As early as the 1930s, thanks to the work of radio astronomy pioneers Karl



this versatile meter is dependable– and it's a workhorse!

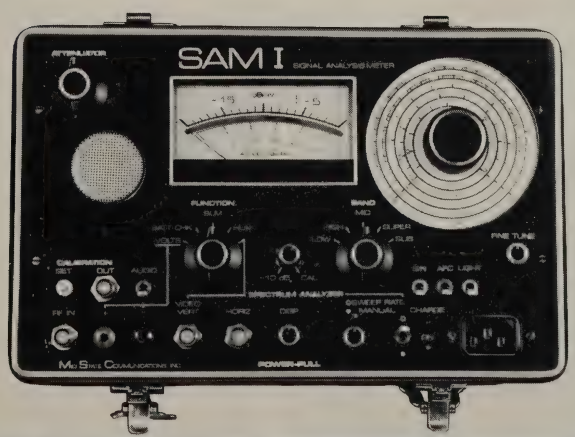


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DIAGRAM 4

INTELSAT-V SPACECRAFT

Jansky and Grote Reber, it was realized that there are within our galaxy several discrete and powerful sources of radio noise, originally termed 'radio stars', but in general associated with the remnants of supernova explosions in historic times. The four most useful of these (for our purpose) are in the constellations of Cassiopeia, Taurus, Cygnus and Virgo. Cygnus A is in fact an extragalactic source, apparently two galaxies in collision, very close to an X-ray source, Cygnus X, which may be associated with the presence of one of the theoretically predicted and infamous 'black holes'. Cassiopeia A is the brightest source at 4 GHz, and has a flux density that is changing in a steady and predictable manner (unlike the sun), making it a prime candidate for system calibration. Light (and radio signals) from the supernova reached earth around A.D. 1702 after a journey of 10,000 years, and the flux density has decreased exponentially since that date, the present rate of decay being between half and one percent per year.

The source is currently some 4 minutes of arc in apparent diameter, and is located at coordinates Right Ascension 23h21m11s, Declination +58°32.8'. Present values of flux density are in the region of 9.5 x 10^{-24} W/m²/Hz at 4 GHz and 4 x 10^{-24} W/m²/Hz at 12 GHz. We could now plot a version of Diagram 2 for Cassiopeia A.

Comparing these figures with diagram 1 shows that we are some 30 dB below solar flux density at 4 GHz and even lower at 12 GHz. So clearly this method is only applicable for higher values of G/T. Otherwise the ratio Y becomes very small and subject to measurement error. As it is, it may be worthwhile when measuring low noise ratios to 'slug' the meter with a capacitor across the terminals of its movement, to provide a degree of integration. But the 'radio star' method is fundamentally more accurate than the 'solar', and is a very valuable technique in the assessment of large terminals and radio telescopes.

Next month I shall describe a method for finding the sun's precise position in the sky, as an aid to antenna steering system calibration, and to predict the timings of 'solar outages'—those periods when the TVRO is unusable due to the sun 'lining up with' the satellite and passing through the beam, swamping the receiver with its noise.

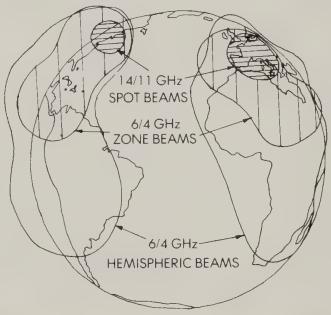

DIAGRAM 5

INTELSAT V FOOTPRINTS

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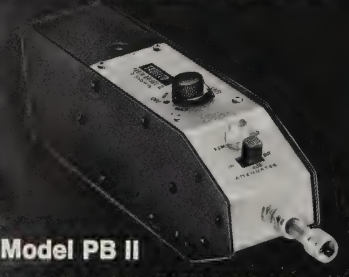

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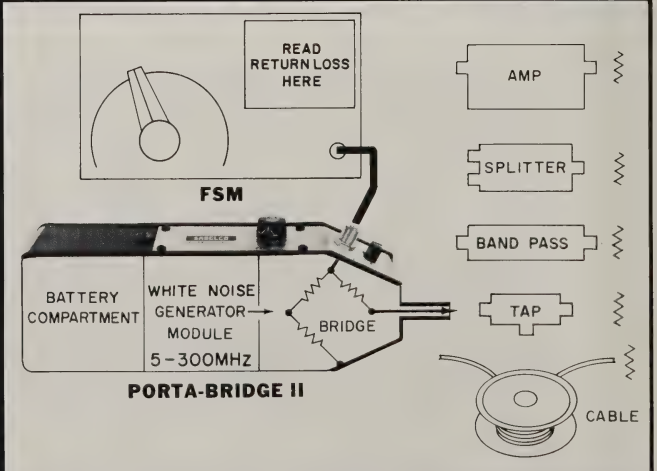

FUNCTIONAL BLOCK DIAGRAM

Ray Daly on Computers In Cable

Ray Daly, President
Computer Cablevision, Inc.
2617 42nd St. NW
Washington, D.C. 20007

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FLOPPY DISKS

One of the funnier sounding devices for computers are floppy disk drives. They are available for most small computers and are necessary for many of the applications computers are used for. Because of the many advantages they offer any computer user, these $500 peripherals are in heavy demand.

But why ever buy a disk drive? Without the capability to manipulate a lot of data, a computer is not much more than a fancy calculator—often used for TV games. But if you are going to use data, i.e., a list of names and addresses, a general ledger, a checkbook and budget program, etc., then a disk drive becomes important. This is why most business computers have one or more floppy disk drives.

A floppy disk is a circular sheet of plastic which is coated with a magnetic film. This is done just like recording tape which is a plastic tape coated with a magnetic film. In order to make handling and using floppy disks easier, it is contained in a flexible casing. This keeps fingerprints and dirt off the disk and can prevent other damage to it. But in order for the disk to be used without ever having to remove the casing, there are slots in this casing where you can see it. To protect the disk from damage which might occur through the slots, the disk (with casing) is usually stored in an envelope when not in use.

There are two sizes of floppy disks. The larger size is 8" by 8". The smaller size, which is the type used on most Radio Shack TRS-80's and Apple computers, is 5 1/4" by 5 1/4". This size of floppy disk is most often referred to as a diskette, which is a trademark of Shuggart. Since this is the most common size of floppy disk, this article will concentrate on this type. Currently there is a price war on floppy disks so the prices can vary widely. But, a 5" diskette sells for about $3.

Just as a record needs a record player and a tape recorder needs a tape recorder, a floppy disk needs a disk drive. Most disks drives for the 5" diskettes are about the size of a shoe box and connect to the computer with a ribbon cable. The power supply is usually self-contained. Disk drives are sold in the $400 to $500 range.

One of the advantages of floppy diskettes is the speed in which information can be stored and retrieved. If you have ever worked with a small computer, you are familiar with the fact that it can take several minutes to load a computer program from cassette. With a floppy diskette, this waiting period is cut down from several minutes to only a few seconds. This fact alone has sold thousands of home computer users on floppy diskettes.

The major advantage for serious applications of computers is the capability to store information on the diskettes. For example, a checkbook and personal finance program needs the storage capacity of a diskette in order to be useful. Trying to operate such programs without a disk drive is foolish.

Storing names, addresses, and other information is a common application for disk systems. On a home computer this list could be a Christmas card list or at business it could be a list of customers. In either case, if someone notified you of a change of address, with a good disk program you could quickly retrieve the information on the person and change the address. Even with an extremely well written program using cassette tapes, you would have to wait for an entire cassette tape recording to load and then you would have to rerecord it. While it can be done, most people would rather do it by hand than spend the time waiting for cassettes.

Most people have an understanding of how cassette tapes are recorded and how record players work. Well, floppy disks are really nothing more than flat magnetically coated records. Just like cassette tapes, you can erase them, record them, and "play" them back. And just like records, you can skip the recording head, the equivalent to the record needle, to any track on the floppy diskette. But unlike records, you do not manually move the record head.

A disk drive is controlled completely electronically from the computer by a computer program once the diskette is in the machine. The set of programs which control the disk drive is called a Disk Operating System (DOS). The usefulness of your disk drive will depend on how well the DOS is written. The most simple will read in the information from the disk drive to a particular computer memory location and little more. The more complex and more common DOS's will allow you to store and retrieve programs and infor-

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mation with single commands in computer languages like BASIC. With this capability, programmers can easily write mailing list programs and other programs using the disk.

The Disk Operating System is usually stored on the diskette. What you do to start the disk operating system is to run a machine language routine to load a program called "Bootstrap." In a Radio Shack TRS-80 this short routine takes up only a few bytes in the Level II ROM. It loads the bootstrap program and then executes it. Then the bootstrap program does everything to make the DOS operational. When it is the TRS-80 will say "DOS READY."

At this point you have a variety of commands available, most of which are not important now. One which is used repeatedly is the "DIRectory" command. It presents a list of all files on the diskette. So right away, you can see that one of the functions of DOS is to build and maintain a directory. The directory lists all programs and other files of data which are stored on the diskette. Also in the directory, but hidden from the user, is a record of which

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tracks are used and which are available on the diskette. This is important because you want to make sure that DOS does not accidently write oyer (erase) any existing files.

Actually files are not erased by the DOS, but they are "KILLed," but there is little blood and guts. But there can be both if a programmer finds that he has just accidentally KILLed some hours worth of work!

There is no reason to go on about the details of disk operating systems. But I should mention that there are several available for the Radio Shack TRS-80. Radio Shack itself recently released version 2.2 of their DOS and it is supplied with any of their drives.

Prior to that time there were lots of problems with version 2.1. This prompted a company called Apparrat to produce what they call NEWDOS which corrected most, if not all, of the problems. They also added several nice (utility) programs. It is available for $50 or for $95 with a whole set of extras.

Also, the original author of Radio Shack's 2.1, Randy Cook, has produced a new version called VTOS 3.0. From our review it appears to be the best available, except that some of the extras on NEWDOS are nice. It is also available for $50.

TRSDOS, NEWDOS, and VTOS 3.0 are almost completely compatible and very much alike. But there is another DOS which is very different. That is CP/M which is the most popular DOS outside the TRS-80 & Apple market. It is of little value, at this time, for the TRS-80 owner, but it may become useful for particular applications.

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Continued From Page 35

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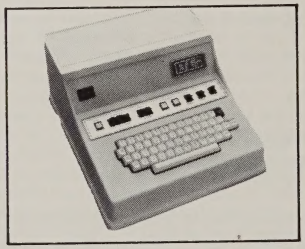

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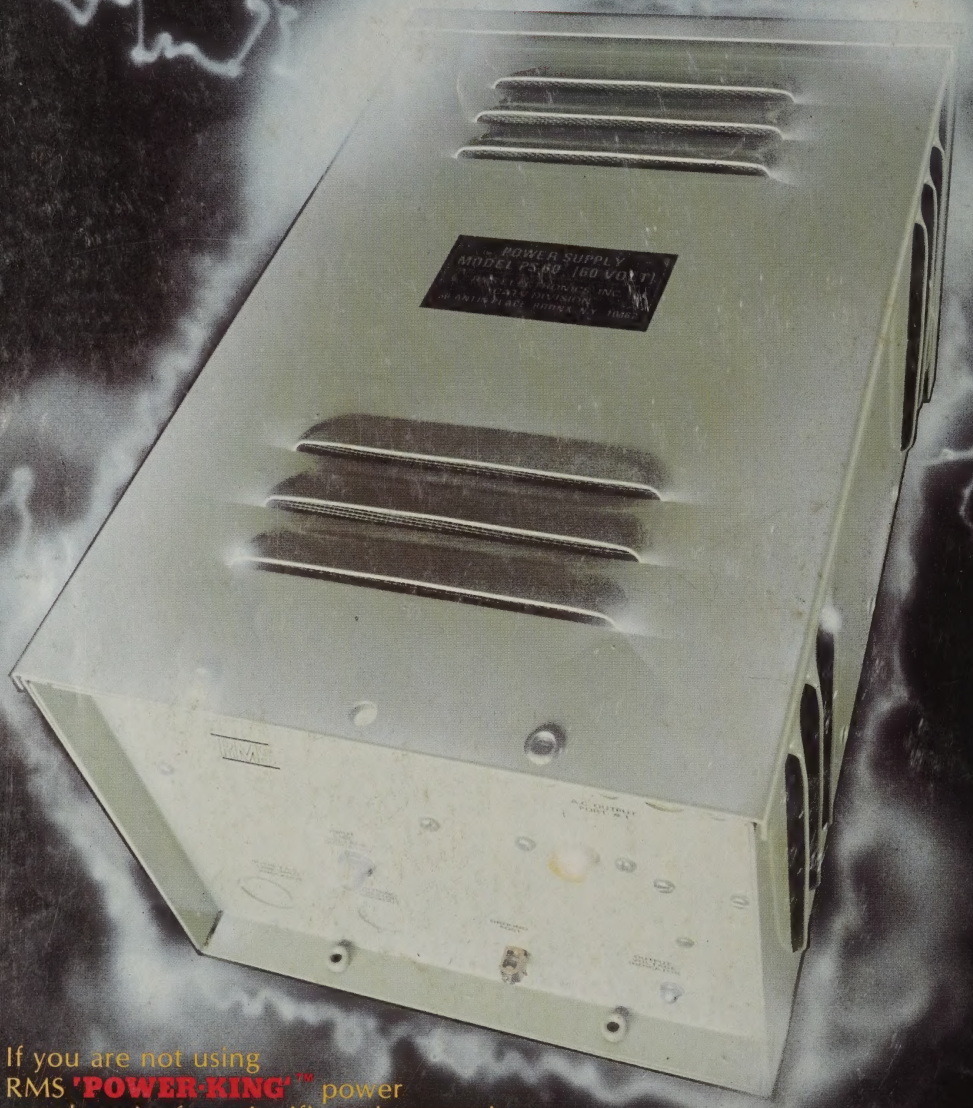

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